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VOLTAGE STABILIZER FOR ELECTRICAL ENERGY TRANSPORTATION AND DISTRIBUTION APPLICATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of electrical energy transportation and distribution, and in particular to a voltage stabilizer/booster that regulates output voltage in incremental steps.

2. Description of Related Art

Problems with the regulation of voltage in electrical energy distribution are known in the art, as are techniques and systems that mitigate the problem.

Autotransformers are commonly used to regulate and/or boost an input voltage to provide a constant output voltage regardless of voltage drops on the input. Typically, such autotransformers are controlled by static or mechanical switches, or via the use of motorized, continuously adjusted autotransformers. Such equipment is typically expensive, and/or somewhat unreliable.

BRIEF SUMMARY OF THE INVENTION

It is an object of this invention to provide a voltage stabilizer that can be used at different electrical energy voltage levels, capable of being installed in single-phase or three-phase networks, to provide a regulated output voltage.

This objects and others are achieved via a voltage stabilizer consisting of one or more electromagnetic devices of transformer type, and which, in incremental steps, regulates the output voltage, particularly within electrical networks with large voltage drops.

The basic regulation device consists of a transformer with a primary dual or quadruple winding, and with a simple secondary winding, that is configured to withstand the supply line's full intensity. The secondary is configured to lie in series between the supply input and the regulated output, and may be positioned before of after the configurable primary branch. Via appropriate configurations of the primary windings,

corrections are made to the output voltage, with the purpose of keeping it within pre-set margins.

This basic element offers features of very considerable economy, robustness and efficacy, the output discretisation being five or nine-step, which makes the invention of interest to installations where there is a major problem of voltage regulation and where a coarse regulation is required at around the nominal voltage value.

Nevertheless, should greater resolution be needed, the invention admits the use of devices in series, with regulations stepped 4:1.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained in further detail, and by way of example, with reference to the accompanying drawings wherein:

FIG. 1 illustrates an example diagram of a single-phase voltage stabilizing device in accordance with this invention, wherein the secondary winding is placed after the primary branch, thereby allowing the transformer power to be reduced, at the cost of not fully exploiting the range of voltage regulation available.

FIG. 2 illustrates an example diagram of a single-phase voltage stabilizing device in accordance with this invention, wherein the secondary winding is placed before the primary branch, thereby fully exploiting the range of voltage regulation available from this device.

Throughout the drawings, the same reference numerals indicate similar or corresponding features or functions.

DETAILED DESCRIPTION OF THE INVENTION

The voltage stabilizer of this invention may be embodied for a single-phase transformation, or thrice replicated for use in a three-phase network. In a three-phase application, independent control of each phase may be provided, or a common control, using multi-pole switches, may be employed, as will be evident to one of ordinary skill in the art in view of this disclosure.

There are two variants of the invention, distinguished by whether the line compensation (secondary coil) lies "downstream" (FIG. 1), or "upstream" (FIG. 2) of the primary branch, which lies parallel to the input supply in each variant. The downstream compensation, shown in figure 1, allows the main transformer's power to be reduced, at the price of not exploiting to the full the magnetic circuit at non-nominal voltages. There is full exploitation in upstream compensation, the scheme for which is shown in figure 2.

In each of the variants, the voltage stabilizer comprises a transformer, trip/contact/relay elements, and a controller. The controller (not illustrated) controls each of the switches/relay elements SC, SR1, and SR2, as detailed below, and is preferably implemented as a microprocessor that measures the output voltage Vout. The switch/relay SC is a power-cutting element that controls whether to engage the transformer to effect an increase or decrease in the output voltage.

The transformer comprises primary coils P1 and P2, and secondary coil S. The primary coils P1 and P2 are configured, via the switch SR1 to be either in parallel, or in series, with each other, and in parallel with the input supply voltage (FIG. 1), or the output supply voltage (FIG. 2). The switch SR2 determines the direction of coupling (polarity) between the primary P1, P2 and secondary S coil arrangements. The primary coils P1 and P2 are substantially identical to each other, and have substantially equivalent coupling to the secondary coil S.

The configurations shown in FIGs. 1 and 2 allow for five possible states of the transformer arrangement, as follows:

With SC in the position illustrated, the secondary coil S is bypassed, and the primary coils P1, P2 are disengaged. In this state, the output voltage Vout will equal the input voltage Vin. Preferably, this state is the default state, thereby allowing a continuous

output voltage in the event of a failure of one or more of the elements comprising the voltage stabilizer.

With SC in a position opposite to that illustrated, the secondary coil S is placed in series between the input voltage Vin and the output voltage Vout, and the primary coils are engaged. In this state, the output voltage is given as:

$$Vout = Vin + Vs,$$

Where Vs is the voltage across the secondary coils S.

At the positions illustrated, the primary coils are coupled in series with each other, via SR1, and the coupling, via SR2, places the voltage Vs across the secondary coil S in phase with the input voltage Vin. Assuming that the number of turns in each primary is Np and the number of turns in the secondary is Ns, the voltage across the secondary coil S, and the output voltage are given as:

$$Vs = Vp*Ns/(2*Np), \text{ and}$$

$$Vout = Vin + Vp*Ns/(2*Np),$$

where Vp is the voltage across the primary branch, and the 2*Np term is due to the fact that two primary coils, each of Np turns, are connected in series within this branch. When SR2 is in the position opposite to the position shown in the figures, the phase of the induced voltage in the secondary S is reversed, and

$$Vout = Vin - Vp*Ns/(2*Np).$$

When SR1 is in the position opposite to the position in the figures, and SR2 is as illustrated, the primary coils are connected in parallel. In this state, the voltage across the secondary coil S, and the output voltage are given as:

$$Vs = Vp*Ns/Np, \text{ and}$$

$$Vout = Vin + Vp*Ns/Np.$$

When SR2 is in the position opposite to the position in the figures, the phase of the induced voltage in the secondary S is reversed, and

$$Vout = Vin - Vp*Ns/Np.$$

In FIG. 1, Vp corresponds to Vin, whereas, in FIG. 2, Vp corresponds to Vout. Table 1 illustrates the output voltage for each state of the switches/relays SC, SR1, SR2, wherein "0" corresponds to the de-asserted states illustrated in the figures, and "1" corresponds to the asserted opposite state.

SC	SR1	SR2	Vout FIG. 1	Vout FIG. 2
0	-	-	Vin	Vin
1	0	0	Vin(1+0.5*Ns/Np)	Vin/(1-0.5*Ns/Np)
1	0	1	Vin(1-0.5*Ns/Np)	Vin/(1+0.5*Ns/Np)
1	1	0	Vin(1+Ns/Np)	Vin/(1-Ns/Np)
1	1	1	Vin(1-Ns/Np)	Vin/(1+Ns/Np)

TABLE 1

As illustrated, the circuits of FIGs. 1 and 2 provide five incremental steps of voltage adjustment, corresponding to increments of 0.5*Ns/Np. When four primaries are provided, the switch/relay SR1 is configured to provide one, two, three, or four coils in series, thereby providing incremental steps corresponding to increments of 0.25*Ns/Np.

In a preferred embodiment of this invention, the controller is configured to measure the output voltage Vout periodically, and correspondingly adjusts the switches/relays SC, SR1, SR2 as required to incrementally increase or decrease the output voltage. Preferably, when a change of state of SR1 or SR2 is required, SC is deasserted to disengage the primary coils before the change of state is introduced.

The foregoing merely illustrates the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the invention and are thus within the spirit and scope of the following claims.